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ABSTRACT

This study examined enrollment trends in high school mathematics and science courses among black females and compared their patterns with those of other groups. It also sought to determine conditions that seemed to enhance enrollment among black females. Data are reported on questionnaire responses from teachers in 20 schools; school visits aided in interpreting the survey data. Black females comprised nearly one-third of the enrollees in general mathematics, but only one-sixth of the students taking top-level mathematics courses. Consistently, black males were lowest on the course ladder and black females just above them. Enrollment for blacks lagged considerably behind that for whites. The enrollment trends were more similar between black males and black females than between black females and white females. Similar patterns were found in science courses. In mathematics, level of teacher experience at the present school, teacher involvement in decision-making, and teacher satisfaction were most strongly correlated with enrollment. In science, satisfaction was most strongly correlated with enrollment, with experience and decision-making lower. School climate was related to enrollment in science, but not in mathematics. Specific differences between schools with high and low enrollment were also reported. (MNS)

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MINORITY FEMALES IN HIGH SCHOOL MATHEMATICS AND SCIENCE

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Report from the Program on Student Diversity and School Processes

Wisconsin Center for Education Research
University of Wisconsin
Madison, Wisconsin

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Appendix A lists the schools that participated in the study. It does not list all of the people associated with those schools who made the study possible. Those people would include superintendents, research directors, principals, counselors, and students in some instances. In addition to individuals in the participating schools, several persons at the Wisconsin Center for Education Research made immeasurable contributions. Mary Evans Sias and Harold Gates served as research assistants at various stages of the project; Rubie Harris took full responsibility for surveying the counselors in the schools; and Michele Trepanier was most helpful in compiling much of the enrollment data. I am especially indebted to Kay Schultz, who served as project secretary throughout, and to Gary Lindle who was responsible for most of the statistical analyses. I want to thank Jock Evanson as well for his help on the analyses.

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I. WOMEN AND MINORITIES IN MATHEMATICS AND SCIENCE

OVERVIEW

The science and engineering labor force of the United States contains relatively few women or members of minority groups. Women hold only 11 percent of all of the doctorates in science, and most of these are in the social and behavioral sciences rather than in the physical sciences and engineering. Women constitute about 7 percent of the chemistry doctorates, 8 percent of those in mathematics, and less than 1 percent of the engineering doctorates. Racial and ethnic minority groups are even more poorly represented. Of persons with doctorates in chemistry, blacks, Hispanics, and American Indians combined are 2 percent.[1] Nor do current enrolment patterns suggest that dramatic changes are likely in the near future. Of the students enrolled in the physical sciences at the graduate level, 1.5 percent are black; .8 percent, Hispanic; and .2 percent American Indian. The figures for minority women are infinitesimal. Consider the case of black women. About 3 percent of all social and behavioral scientists, but less than 1 percent of persons in the physical and biological sciences and in engineering are black females. Approximately 72 percent of the black women in science and engineering as compared with 28 percent of the white women are in the social and behavioral sciences; for black men, the figure is 17 percent (Women and Minorities in Science and Engineering, 1982).

The study reported here sought to determine whether the underrepresentation of minority women might begin with their differential course-taking

during the high school years. Specifically, the research (1) examined enrollment trends in high school mathematics and science among minority females and (2) compared the minority female patterns with those of other groups. On the assumption that some schools might have had more favorable patterns than others, the study also looked for such schools and the conditions within them that seemed to enhance enrollment among minority females.

The study was undertaken because of the paucity of information on the high school experiences in mathematics and science of minority females. Research does exist on minority students, however, and it generally shows lower participation rates for these students than for their majority counter parts. That was the result of a 1980 survey on high school seniors which found that 50 percent of the whites, 39 percent of the blacks, 38 percent of the Hispanics, and 32 percent of the American Indians had taken algebra II (U.S. Department of Education, 1981). Moreover, minority seniors were significantly more likely than non-minority ones to have taken remedial mathematics classes. The same proportion of blacks and whites — 20 percent — had take physics, but only 22 percent of the former as conpared with 39 percent of the latter had studied chemistry. These findings would lead one to expect low rates of participation among all minority students, female as well as male.

But the research on women and mathematics might lead to a different expectation. Until recently, most of that research uncovered significant differences in the enrollment patterns of males and females. For example, Project Talent data gathered in 1960 on over 400,000 high school students found a higher percentage of males than of females taking college-preparatory

mathematics. A follow-up study in 1963, involving student who had been ninth graders at the time of the original survey, found that sex differences in course-taking had persisted (see Wise, Steel, and MacDonald, 1979). Similar results emerged from the National Longitudinal Study of Mathematical Abilities (NLSMA), conducted between 1962 and 1967.[2]

Recent studies show more of a convergence between the sexes, however. The Women in Mathematics Project, carried out in 1978 with over 1700 twelfth graders, uncovered similar educational histories for males and females. Both groups were equally likely to have had or to be enrolled in calculus, computer programming, trigonomentry, and other mathematics electives. In fact, of the twelve courses the Project covered, for only three -- probability/statistics, algebra II, and accounting/business mathematics -- did male and female trends diverge. The 1977-78 National Assessment of Educational Progress (NAEP) also noted few differences in course taking. Of nine subject areas, significant male-female discrepancies occurred for only two: precalculus/calculus and trigonometry (Armstrong, 1981).[3]

Because there are few studies on minority females, we do not know whether their experiences parallel those of majority females. We cannot be certain, then, that sex differences are narrowing for all segments of the population. Indeed, there are indications that the course-taking patterns of minority females are not identical to those of minority males. Consider the results of a small-scale study conducted among juniors and seniors at Wayne State University. The study found that black females who were majoring in the sciences had taken less mathematics than all other science majors, including

black males. In fact, the black females had had even fewer years of mathematics than white males who were in non-science fields (Sie, et al., 1978). But another study at the college level, conducted among freshmen at the University of Washington, found that black females were as likely as black males to have had at least one general or remedial mathematics course in high schoool, and both groups were more likely to have had such a course than was true of white freshmen. The participation rate in general or remedial mathematics was 43 percent for black males and females, 11 percent for white females, and 5 percent for white males (Remick and Miller, 1977). In contrast, an analysis of four Oakland, California high schools found differences among black males and females at the level of algebra I but not in the higher level courses. Interestingly the females were more heavily represented in algebra I (Matthews, 1980).

Nor do the studies on science participation consistently show convergences between minority males and females; the National Longitudinal Study of the High School Class of 1972 (NLS) is illustrative. First, more of the males than of the females indicated as college freshmen that they planned to major in the natural sciences; moreover, none of the black females expressed an interest in engineering as a major. Second, these freshmen had not had similar preparation in science; on the average, the females had taken fewer high school courses in science than had the males (Dunteman, et al., 1979; Thomas, 1981). Yet, other analyses show closer similarities. The University of Washington study, for example, found that among the black freshmen about 90 percent of both sexes had taken biology, about 50 percent, chemistry, and about 15 percent, physics. Among whites approximately 90 percent of the

females and 80 percent of the males had taken biology, while the figures for chemistry were 60 percent and 76 percent respectively and for physics, 15 percent and 76 percent. A survey conducted among secondary school students who were interested in science discovered that almost none of the black students had participated in honors or advanced placement programs in science, but no sex difference stood out (Erlick & Lebold, 1977).

As all of this should indicate, the results on minority male-female enrollment are somewhat mixed. The studies that report differences do not invariably show them to be in the same direction. The inconsistencies perhaps stem from the use of small, and localized samples in most of the studies. It could be, too, that the experience of college students cannot be generalized to the larger high school population. The present study proceeded on the assumption that enrollment trends among minority females could best be revealed through an examination of a sizable set of diverse high schools.

THE CONCEPTUAL FRAMEWORK

The study aimed to describe minority female enrollment patterns and analyze reasons for dissimilarities among schools in those patterns. In searching for possible reasons, the study focused on the organizational characteristics of schools, i.e., it built on a perspective that treats schools as formal organizations. Drawing on that perspective, the study was designed to measure the influence of certain structural and staffing traits on mathematics and science participation. The organizational emphasis was chosen

(1) to supplement the social-psychological or attitudinal focus evident in most of the available studies and (2) because several studies on student achievement had found organizational conditions to be important.

Attitudes and Participation

The handful of studies on minority students in precollege mathematics and science give greater attention to attitudinal influences than they do to contextual ones. Matthews (1980), for example, looked at race and sex differences in perceptions about the usefulness of mathematics, anxiety about mathematics, and enjoyment of the subject. She found no sex differences among the black students in anxiety, but she discovered that the males were more likely than the females to view mathematics as useful for future careers. Cresswell (1981) also examined attitudes about mathematics, using for his sample a group of black and Chicano junior high school students. The females from both ethnic populations expressed somewhat more positive attitudes than the males, but the latter had the higher test scores. Currently, Parsons and her associates are conducting a large scale study on race, gender, and mathematics that draws heavily on attributional theory to account for participation and performance trends.[4] Because of these and related studies, one can turn to the literature for some insights on the relationship between the attitudes of minority females and outcomes in mathematics.[5]

School Context and Participation

The literature offers little for the observer who wants to understand the effect of school conditions on mathematics and science outcomes for minority females, however. This represents a serious deficit, for there are signs that the context can be important. These signs appear in some of the research on the general topic of student achievement as well as in analyses on women and minority students specifically.

An inquiry by Lezotte and Passalacqua (1978) on mathematics achievement represents the first category. The researchers examined test scores for 20 elementary schools in a single urban district and two predictors of those scores: prior achievement in mathematics, and school attended. They found that by including school attended, they could account for more of the variance in test scores than the measure of prior performance alone could explain. Although the study did not seek to identify the in-school factors that made the difference it does seem to confirm the contention of school ethnographers that the setting matters. One ethographer, Ogbu (see, 1981) for example) maintains that too few educational analysts look at the school as a social organization, i.e., as a context within which social roles and identities develop and social forms emerge.

A study by Casserly (1980) illustrates the body of work on school effects and female student outcomes. She examined 13 high schools that had large numbers of females taking advanced placement (AP) course, not all of which were in mathematics. Based on the results of her observations and interviews, Casserly concluded that female participation in AP mathematics, physics, and chemistry was highest in schools with flexible curricula and with teachers who

recruited students to their courses. In 1980 Fennema called attention to the fact that the Casserly research had uncovered school differences. Earlier, Fennema and her associate (Fennema and Sherman, 1981) had obtained results that also supported the view that conditions in schools might be associated with high female partipation in elective mathematics.

Finally, a few studies on minority students and mathematics participation show the importance of school effects. One analysis (Marrett and Gates, forthcoming) of enrollment patterns in six predominantly black high schools found greater contrasts among the schools than between the sexes. Moreover, the school differences did not seem to be attributable to differences in student composition. Preliminary analyses by Jackson (1982) indicate that the mathematics achievement of black students is more closely associated with school structure than with student attitudes. Though it was not on mathematics, a review of the research on ethnicity and achievement is relevant to the issue of school effects. Kee (1972) examined various studies on students from four ethnic groups and concluded that socio-economic status made less of a difference for performance than did various in-school influences. There is, then, precedence for the emphasis the present study placed on school conditions. More importantly, there are clues that such an emphasis can enlarge substantially our knowledge about the educational encounters in mathematics and science of minority females.

School Organization and Participation

Most of the literature cited thus far points out that settings differ, but it does not pinpoint the significant differences. Some sources are quite

explicit on the matter, however: they mark the organizational characteristics of schools. Consider the contention of Bidwell and Kasarda (1975). The authors assert that the report, Equality of Educational Opportunity, offered too narrow an approach to the topic because it failed to look deeply at organizational structure and practices. They lament the fact that the authors "did not consider how between school differences in such organization attributes as the division of labor, formalization of teaching activities, supervision of teaching, or the morphology of control might have mediated or otherwise affected relationships between inputs to schools and pupil achievement" (p. 56). Bidwell and Kasarda included several of these attributes in their study on student achievement in order to correct what they saw as the restrictiveness of some prior research. The present study reviewed the Bidwell and Kasarda results in addition to those from several other studies and selected three organizational variables for analysis: school climate, decision making structure, and level of teacher experience.

School climate. Several studies highlight the importance of the temper or climate of a school. The authors of the recent Coleman report on public and private schools (Coleman, Hoffer, and Kilgore, 1982) ascribe the achievement differences that they found between the two types more to climate than to student selectivity. They propose that public schools with few behavioral problems -- low absenteeism rates, high class attendance, and few fights and threats to teachers -- have achievement rates that compare favorably with those for private schools.[6]

One of the most detailed studies on climate comes from Brookover and his associates (Brookover, et al., 1978). The researchers sampled 159 public elementary schools in Michigan, measured the expectations and perceptions of students, teachers, and principals, and developed two compositional measures: mean socio-economic status and percent white. The dependent variable was the mean achievement of students in the fourth grade in each of the schools, based on state-administered tests in reading and mathematics. According to the authors, the compositional measures accounted for little of the variance in test scores beyond that which climate explained. Furthermore, climate made more of a difference in the predominantly black than predominantly white schools.

The Brookover team spent time in a few of the schools to understand better the climate and the ways in which it might have affected cognition and learning. They found that interaction -- teacher-teacher and teacher-student -- was not the same in the high achieving schools as compared with the others: the quality of the contact was higher in the former. Brookover and his associates assert that in general one should look at the character of the setting and not of the students, for "neither racial nor socio-economic desegregation of schools automatically produces higher school achievement. If the unfavorable social-psychological climate which typically characterizes segregated black and lower SES schools continues to prevail for the poor or minority students in the desegregated schools, desegregation is not likely to materially affect achievement of the students" (p. 317).

Decision-making structure. Two different research traditions suggest indirectly a link between teacher participation in decision making and

positive student outcomes. The first is the literature on coordination; the second, that on organization innovation. A study undertaken in a group of Los Angeles schools with heavy concentrations of minority students found that program coordination — measured as interaction among teachers concerning problems and practices — was positively associated with reading gains (Armor, et. al., 1976). If one generalizes from a project on the improvement of secondary schools (Klausmeier, Lipham and Daresh, 1980), it would seem that coordination is most likely to be effective when school personnel can engage in dialogue with one another and share in the making of key decisions. Apparently, then, participation affects student outcomes through its relationship to coordination and planning.

A wide literature shows that innovation in organizations is associated with particular structural traits. Aiken and Hage (1971) found that social welfare organizations with wide staff participation in decision making were more likely to innovate than were highly centralized organizations. Studies on change in American universities and colleges (Blau, 1973; Clark, 1968) and on creativity in science institutions (Ben-David, 1960) confirm the finding. It could be that participants are more likely to search for new ways of doing things when they have the power to institute the innovations If we think of the recruitment to mathematics and science courses of previously underrepresented groups as an innovation or at least a non-traditional development, then we would expect a relationship between teacher participation and minority female enrollment.

Direct evidence for the connection comes from a study on successful schools (Wellisch, et al., 1978). The analysis included as one of its

organizational measures, responsibility for instruction; this measure tapped teacher estimates of their participation in decisions concerning instruction, materials, and school-wide evaluation. Significantly, administrators involvement was higher in the successful schools than in the others. In other words, total control by teachers was not associated with school success, as measured by student performance. This finding indicates that shared decision making and not abdication by administrators should bear strongly on positive student outcomes.

Teacher experience. Bidwell and Kasarda determined for the school districts they studied that investments in teachers contributed to student achievement. They based this conclusion in part on the fact that staff qualifications (percent with masters degrees) bore positively on student achievement while an administrative ratio measure had a strong negative relationship. Other studies support the argument that teacher background in general, and teacher experience in particular, can be important. That generalization emerges from a study on eighth grade student test performance. Pulos, Stage and Karplus (1981) administered mathematics reasoning tests to 260 students in three urban schools that differed somewhat in teacher characteristics. In one of the schools none of the mathematics teachers had majored in the subject, and on the average they were less experienced than their counterparts in the other two schools. It was this school in which the researchers found the lowest test scores. The Jackson study corroborates the theme that teacher experience is important. It is one of the differences he has found among schools with contrasting mathematics performance and participation rates.

A report from the Minority Engineering Education Effort (ME^3) describes the situation for schools in three different cities. In one city, the school with the poorest mean student performance in mathematics had not had a mathematics major for twenty years. Contrastingly, a school with better performance had only mathematics majors on its staff, and these teachers averaged ten years of experience. The ME^3 analysis compared two schools of similar racial makeup in a second city and found that the teachers in the higher performing schools had nearly twice the level of experience that typified the low achieving school.

School Composition and Program Characteristics

The present study highlighted climate, decision-making structure and teacher experience because they had emerged as significant in other studies. But it examined school composition and program characteristics as well, given the mixed results the literature reported for those measures. Although Coleman, et. al., Jackson, and Brookover, et. al., found compositional differences to be insignificant, Bidwell and Kasarda did not. Moreover, composition could have little explanatory power for elementary mathematics performance in elementary schools and yet be quite important for enrollment patterns in high school mathematics and science. Finally, if we want a fuller understanding of the conditions influencing black female enrollment in mathematics and science, we will need to include a range of variables in our models and compare their relative effects. For these reasons, the present study gave attention to school composition, but it was expected that composition would bear less on enrollment than would school organization.

Schools vary widely in the resources and curricula that are available to students. The present study explored certain aspects of the mathematics and science programs to see if differences among them were associated with differences in enrollment. But there was no specific expectation about how those differences would contribute to enrollment. In summary, the study tested the following hypotheses:

(1) The more positive the climate, the higher the level of minority female enrollment in mathematics and in science.

(2) The greater the level of teacher participation in decision making, the higher the minority female enrollment.

(3) The more experienced the mathematics and science teaching staff, the higher the minority female enrollment.

(4) Differences in organizational conditions -- climate, decision making structure, and staff experience -- account for more of the variance in minority female enrollment than do differences in student body composition.

NON-PARTICIPATION: SOME CONSEQUENCES

An analysis of minority female participation rates seem timely, given the growing national interest in precollege mathematics and science and the expansion of programs for increasing minority student involvement in those fields.[7] These efforts flow from the fact that large numbers of high school graduates in the United States find themselves excluded from an ever-widening array of occupations because they are inadequately prepared in mathematics and

science. The physical, biological, and social sciences, engineering, and various other technical fields are closed to individuals who possess only a rudimentary knowledge of mathematics. Consequently, such individuals have fewer and fewer career options in a society that values and promotes scientific and technological expansion.

Limited exposure to mathematics and science in a society such as ours affects the welfare not only of the individual, but that of the entire nation as well. A democratic nation with an electorate that finds technical matters unintelligible and baffling cannot thrive. Its survival is especially threatened if identifiable and sizeable groups within it cannot participate in shaping the public policies that must guide many scientific and technical endeavors. We should be disturbed then, by the fact that minority women are overrepresented in the ranks of what some describe as the "scientifically illiterate."

II. THE RESEARCH DESIGN

DATA COLLECTION PROCEDURES

The study consisted of two phases: a survey phase and a school visit phase. In the first, carried out during the Spring of 1980, questionnaires were sent to all mathematics and science teachers and to a sample of homeroom teachers in forty-four secondary schools. To obtain schools for the survey, we first identified senior high schools (10-12) in the United States that were cited in the Directory of Elementary and Secondary School Districts as having between 150 and 3,000 students. We then selected schools in which the percent black was (1) thirty percent or less: (2) between 40 and 55 percent; or (3) 70 percent or greater. Of the districts which contained schools meeting our criteria on size and racial composition, we contacted 178 and requested permission to include the given schools in our study. Thirty-six districts encompassing the forty-four of the schools granted that permission. In these schools, blacks constituted most of the minority population. Thus, the results as given actually describe black-white enrollment trends.

The Survey Procedures[8]

In first phase of the project, we were interested primarily in enrollment patterns for elective mathematics and science courses. We obtained enrollment data from two groups of respondents: the relevant subject matter teachers, and a set of homeroom teachers. We asked each mathematics and science teacher to indicate all elective courses he or she was teaching and the race and sex

of each student in the course. From the homeroom teachers, we asked for two sets of figures: the race-sex make-up of the homeroom, and the race and sex of students from that homeroom taking certain mathematics and science courses. We used the information on homeroom composition to determine the race-sex distribution of the student body in each school. The Directory from which we selected schools gave the racial distribution only. We requested the enrollment figures from a sample of homeroom teachers, chosen in proportion to the total number of teachers in the school.

In addition to items on enrollment, the questionnaire sent to subject matter teachers contained questions about the school curriculum, about the quality of school facilities, and about perceptions of conditions influencing minority student enrollment in mathematics and science. We also asked the individual respondents to report on their involvement in the decision making process in the school, their level of satisfaction with themselves, their students, and the school in general, and on their own personal characteristics, including age, ethnicity, and years spent teaching.

The study included 44 schools, but the analyses reported here cover a sub-sample of 20 schools. This approach is used for two reasons. First, as we began the analyses we found the data on all courses, not just those on the highest level, especially insightful. We could include, then, only those schools on which we had obtained complete enrollment data for the mathematics and science programs. Second, the larger sample included a couple of schools that were more than 99 perent black; we eliminated them because they would have been inappropriate for analyses on the joint effects of race and sex. We determined that the results from the subsample could be generalized to the

larger set by reviewing enrollment patterns in the highest level courses; for those courses we had comparable data from the larger sample as well as the subset.

School Visits[9]

The survey data, and the other descriptive information we compiled on each school, could give us only a limited sense of its character, its distinctive features. Moreover, we could not hope to learn of the successes and failures, the desires and frustrations of teachers merely from a survey instrument. To gain a better understanding of the kind of student population and community being served, of plans and ideas for teaching mathematics and science which teachers might have had, and in general of the experiences of teachers, counselors, and administrators, we aranged for visits to some of the schools.

The visits were designed to be informal. The activities in which we engaged during the one-day visit we made during the 1980-81 school year to thirty schools varied, although usually we sat in on a few mathematics and science classes; talked with teachers and other members of the staff regarding the school in general and the mathematics and science programs in particular; and discussed with counselors their roles and responsibilities in providing guidance to students on both academic and non-academic matters. Although we sought only only one piece of quantitative data, descibed below, we found the visits invaluable for helping us interpret what we had obtained from the survey and for enlarging our perspective on the teaching of high school science and mathematics.

With reference to data, we asked each school to give us enrollment figures, by race and sex, for every mathematics and science course being offered. As noted earlier, the survey centered on elective courses. From the survey responses we were able to calculate the total number of students enrolled in a course and the proportion of those students which the various race-sex categories represented. We could not look at course taking patterns within any of these categories, however. We found few black females in physics, for example, but did not know whether they were concentrated in other science courses, or whether they simply were unlikely to be taking any science. Complete enrollment information was necessary if we were to select one of these alternatives.

DATA AGGREGATION PROCEDURES

Measuring Mathematics Enrollment

To make the mathematics data comparable across the schools the enrollment figures were aggregated in two ways: by course title, and by course prerequisites. The course titles tended to be similar: every school offered algebra I, geometry, and algebra II. But for several courses, the title alone was not informative; it did not indicate whether the course was an introductory, intermediate, or advanced one. For such courses we reviewed the admission requirements. If there was no prerequisite, we classified the course as a general one, even if the term "advanced" appeared in the title. Several of the schools offered advanced general mathematics for seniors, but usually this was a course for students who had taken no mathematics in senior

high school. Such courses were different from the ones on advanced mathematics for which geometry and algebra II usually were the minimal requirements.

We grouped the course into five main categories, roughly approximating a sequence: general mathematics; introductory algebra; geometry; algebra II; and calculus and other advanced subjects. We included courses on business and consumer mathematics in the first category. The second category contained all of the courses which introduced students to algebraic concepts; the most common titles were pre-algebra and algebra I. We tried to restrict the third category to those geometry courses that had admission requirements. Courses open to students with no prior mathematics--experimental geometry and geometric design were two examples--were placed in the general mathematcs category.

Some of the schools offered no calculus or had small numbers enrolled in it. Additionally, there was considerable diversity in the kinds of courses offered at the highest level. For these reasons, we counted the figures from calculus along with those from other courses such as elementary analysis, trigonometry, statistics and probability, and computer mathematics. Based on the course title approach, "top level courses" are those in category five. The use of titles facilitated comparison between the results of this study and those obtained in several national surveys, because that is the way the surveys generally have reported their results.

Courses with the same title did not always serve the same range of students, however. Hence, to take account of this variability, we also grouped courses on the basis of prerequisites exclusively; with that approach,

course titles were not used at all. Courses that required at least one mathematics course after first-year algebra are classified in the report as "advanced courses." Those that required two mathematics courses beyond first-year algebra are called the "most selective courses."

Described thus far are the different numerators used in the calculations on minority female enrollment in mathematics. The denominators varied as well. In some instances the base was the total course enrollment, i.e., the total number of minority and non-minority students; when the data are reported in that way are referred to as "within course" results. In other instances the base was the number of mathematics students from the given group; in the case of minority females it would have been the number of such students who were taking any mathematics course. Except in a few instances, only those courses at the level of algebra I and beyond were included in these "within group" counts. The set of courses was limited to the algebra I and beyond to make the data comparable across schools. Although all of the schools were listed in the directory as senior high schools, that was not accurate in some instances. Quite possibly, schools with ninth graders would have had larger enrollments in general mathematics than schools with tenth through twelfth graders only. Differences in enrollment patterns, then would have been the consequences of differences in the grades served. The use of the with-in group calculations represented an attempt remove a source of bias in the analyses.

In summary, the following calculations were used for determining minority female enrollment in non-required mathematics courses:

(1) $\frac{\text{number of minority females in top-level courses}}{\text{total number of students in top-level courses}}$

(2) $\frac{\text{number of minority females in advanced courses}}{\text{total number of students in advanced courses}}$

(3) $\frac{\text{number of minority females in most selective courses}}{\text{total number of students in most selective courses}}$

All of the above represent "within course" comparisons. To determine whether the minority females were equitably ditributed in the courses, their proportion at the given course level was compared with their proportion in the school as a whole. The formula used was as follows:

$$\frac{\text{proportion minority female at course level}}{\text{proportion minority female in the school}} \times 100$$

The within-group calculations were developed as follows:

(4) $\frac{\text{number of minority females in top-level courses}}{\text{number of minority females in all mathematics courses}}$

(5) $\frac{\text{number of minority females in advanced courses}}{\text{number of minority females in courses, algebra I and beyond}}$

(6) $\frac{\text{number of minority females in most selective courses}}{\text{number of minority females in courses, algebra I and beyond}}$

In the regression analyses the dependent variable, enrollment of minority females is measured on the basis of (5)

Measuring Science Enrollment

The science courses were grouped first into one of six categories, according to the title of the course: general science, physical science, biology-life science, chemistry, and physics. In the case of one school that offered no physics course, we used the enrollment figures for its most advanced physical science course. Consistent with the approach to the mathematics data, the term "top level" indicates the count for the sixth category.

As a second strategy, we added to the figures for physics the enrollment sums in chemistry and in all other courses that required at least one science unit; astronomy, physiology, and meteorology were some of those subjects. The resulting count is termed here enrollment in advanced science courses. The analysis also looked at the number of minority females in the advanced courses in proprtion to their enrollment in the school. The two measures that appear in the science analyses are these:

(1) $\frac{\text{number of minority females in physics}}{\text{number of minority females in all science courses}}$

(2) $\frac{\text{number of minority females in advanced science courses}}{\text{number of minority females in the school.}} \times 100$

The first was included in the regression analyses.

Some of the calculations are based on overall sample totals. In other words, they denote the sum of students in each race-sex category as reported by all of the teachers who were polled. Collectively, the mathematics teachers described nearly 12,000 students of whom almost one-fourth came from the each race-sex category. The presentation focuses at points on the ways in

which these 12,000 persons were distributed across the courses. Likewise, the aggregate science data reports on the trends for about 9,000 students.

Other calculations use the school as the unit for analysis. For those, we determined race-sex percentages for the individual schools and then pooled the percentages to arrive at results for the full set of schools. This procedure takes account of differences among the schools and allows for comparisons of school-level influences on enrollment. Although different percentages resulted depending upon whether the aggregate sums or school averages were used, in both instances the ranking of the race-sex groups remained the same.

One should remember that the counts were obtained on classrooms rather than on individual students. This means that several students possibly were counted more than once. The discussion that follows sometimes mentions that more males than females were taking a given course. Technically, it means that, in proportion to the male and female totals, the male count for that course was higher.

THE INDEPENDENT VARIABLES

School Organization

Two of the measures -- climate and participation in decision making -- used the responses of all teachers, not just those in mathematics and science. The larger sample was used in those instances on the assumption that the response would reflect the school more accurately. The third measure, teacher experience, had to do with mathematics and science teachers only.

Climate. The study took teacher satisfaction to be indicative of the school climate. Because no data were gathered on individual students, many of the measures in Brookover, et. al., could not be employed. In addition, there was a conceptual reason for focusing on teacher attitude. If a school has few behavioral problems — the key Coleman, et. al., measure of climate — or if teachers feel positively about the students -- one of the indicators in Brookover, et. al., -- then these circumstances should be reflected in teacher satisfaction.

Several items on satisfaction were adapted from other studies. Of the eight that appeared in the questionnaire, for only four was there variation in teacher response and high intercorrelations. Specifically, the satisfaction index that emerged consisted of the following: "How satisfied are you with (1) the extent to which you are able to meet your students' needs; (2) the academic performance of black students in your school; (3) the academic reputation your school has in the community; and (4) the counseling services your school provides?" The responses categories ranged from "very dissatisfied" (1) to "very satisfied" (4).

Participation in decision making. Teachers were asked about their involvement in six decision areas. But responses on two -- hiring and developing evaluation procedures -- were not variable. Hence, the index of participation used in the analyses covered these four areas: budget development, establishment of disciplinary rules, setting of goals for one's unit or program, and development of procedures for reporting student progress. The responses could range from "no involvement" (1) to "substantial involvement" (4).

Teacher experience. The studies that stress this variable fail to indicate which should be more important: the total length of time a teacher has been in the profession, or the time spent in the present position. This study covered both possibilities. Teachers of mathematics and science reported on the number of years they had been teaching and the number of years in the present position.

School Composition

To determine the proportion of black females in each school some of the homeroom teacher respondents were asked to count the number of students in each of the four race/sex categories: black and white males and females. The teachers also indicated for selected mathematics courses the race and sex of each student from the homeroom who was currently enrolled. The course data from the homeroom teachers provided a check on the enrollment data from the subject teachers as well as information on levels of student participation in mathematics and science for the school as a whole. The homeroom compositional data allowed for a comparison between the race/sex composition of the school and that for particular courses. The results showed that within each racial category, males and females were nearly equally represented in the total school population.

The regression models, discussed later in this paper, used the variable percent black of school population as the key compositional measure. But socio-economic profiles of the schools were constructed as well from various sources, including interviews with the principals and information on participation in the free and reduced-price lunch programs.

II. ENROLLMENT IN MATHEMATICS AND IN SCIENCE

GENERAL ENROLLMENT PATTERNS

The analysis focused on differences among schools. But before turning to those differences, let us review the trends for the set of schools taken collectively. The schools in the study were located in several states, but they did not represent a strictly random sample of American secondary schools. Schools in the Southern region were heavily represented among the group of 44: 10 schools were in Georgia and 7 in North Carolina, for example. The sample did include as well 4 California schools and 3 in Ohio. To determine if our results were generalizable, we compared them with enrollment trends other researchers had found. Our data paralleled quite closely those from other regionally based studies, and even more importantly, they corresponded with the findings from national samples.

Consider enrollment in mathematics. Over one-third of the students in our sample of schools were enrolled in general mathematics courses, to which we added technical mathematics, business mathematics, and consumer mathematics (see Table 1). Out of every 100 students, only about 7 were likely to be taking calculus and other higher level courses such as statistics and computer mathematics. The latter figure exceeded the one that Dunson (1969) had found in a study conducted in predominantly black schools within Georgia. But our enrollment figures for the first year algebra course (22.4%) came quite close to his (20.8%).[10] Significantly, the data corresponded even more with national data the Research Triangle Institute (RTI) had collected (Weiss,

TABLE 1. DISTRIBUTION OF STUDENTS IN MATHEMATICS, RESULTS OF THREE STUDIES

COURSES	STUDY		
	Present Study	Dunson Study[1]	Weiss Study[2]
General mathematics	35.6%	49.2%	35.8%
Beginning algebra	22.4	20.8	19.9
Geometry	16.8	9.1	17.8
Other intermediate courses	4.6	8.1	5.1
Algebra II	13.7	10.2	11.7
Calculus; other higher level courses	6.9	2.6	9.7
TOTAL ENROLLMENT	11, 899	27, 156	10,167,991

[1]Charles K. Dunson. A Descriptive Analysis of the Mathematics Curriculum in the Predominantly Negro High Schools in the State of Georgia. Ph.D. dissertation, Colorado State University, 1969.

[2]Iris R. Weiss. Report of the 1977 National Survey of Science, Mathematics, and Social Studies. Research Triangle Institute, 1978.

1978). As was true of our sample, over one-third of the students in that national study could be found in general mathematics; enrollment at that level accounted for over 35 percent of the total mathematics enrollment. The RTI study and our own found enrollment in geometry to comprise about 17 percent of the total. RTI found a higher proportion in calculus and other higher level courses than we did, however. Nonetheless, there were enough convergences to suggest that the patterns we uncovered extend beyond the set of schools we studied.

The results for science also coincided with the outcomes in other research. Nationally, enrollments in the biological sciences surpass those in the physical sciences at the high school level; thus, the overall pattern in these schools conformed with the national one. Yet, there were differences. First, biology drew a larger fraction of the students in the sample (52 percent) than typifies the nation (41 percent, see Table 2). Second, fewer students were taking general science (7 percent) and earth science (4 percent) than national surveys have found (23 percent and 7 percent, respectively). On the other hand, introductory physical science course drew more students (18 percent) than is characteristic nationally (7 percent) while chemistry had the same proportion in both cases (14 percent). Physics and other advanced physical science courses had relatively few students--5 percent—but that tends to be the national trend. Although the percentages in the study differed somewhat from national ones, the distributions were consistent enough to suggest that the study results apply beyond the particular sample.

TABLE 2. DISTRIBUTION OF STUDENTS IN SCIENCE, RESULTS OF TWO STUDIES

COURSES	STUDY	
	Present Study	Weiss Study[1]
General science	6.6%	23.4%
Physical science	18.2	7.4
Biology[2]	52.0	41.0
Earth science	4.0	7.3
Chemistry	14.1	14.3
Physics	4.9	6.5
TOTAL	8,977	9,341,203

[1]Iris Weiss, Report of the 1977 National Survey of Science, Mathematics and Social Studies. Research Triangle Institute, 1978.

[2]Includes all biology and life science courses.

MINORITY FEMALE ENROLLMENT IN MATHEMATICS

Within Course Comparisons

The groups were rather evenly distributed in the sample. Of the 11,900 students, 24 percent were black females; 24 percent, black males; 25 percent, white females; and 27 percent white males. Hypothetically, each course could have had roughly one-quarter students from each category. Yet, that was the result for only two courses: intermediate mathematics and beginning algebra (see Table 3). For the rest of the subjects, some group percentages were higher than might have been expected while others were lower. Black females for example, comprised nearly one-third the enrollees in general mathematics but only one-sixth of the students taking the most top level courses. Contrastingly, relatively few of the general mathematics students (19 percent) were white males, but 40 percent of the students in top level mathematics were from that category.

Consistently, black males were on the bottom rung of the course ladder and black females on the one just above them. Moreover, the male-female differences among blacks tended to be somewhat larger than they were among whites. In algebra II, for example, the number of females exceeded the number of males within the same racial group. Whereas among whites, the figures differed by less than two percentage points, among blacks, the spread was four points. At the top most level, there were more white males that white females, but the count for black females surpassed the one for black males. For white students the results confirm what other recent studies have reported: minimal male-female differences in enrollment. The findings point

TABLE 3. WITHIN COURSE AND WITHIN GROUP DISTRIBUTION, AGGREGATE MATHEMATICS DATA

COURSE	GROUP				
	Black Females	Black Males	White Females	White Males	Totals Within Course
General mathematics					
Within course	29.7%	35.3%	16.0%	19.0%	100% (N=4236)
Within group	43.8	52.9	22.7	25.0	
Beginning algebra					
Within course	27.5	23.9	22.9	25.8	100% (N=2666)
Within group	25.5	22.5	20.4	21.4	
Geometry					
Within course	18.4	14.4	34.6	32.5	100% (N=1999)
Within group	12.8	10.2	23.1	20.2	
Other intermediate					
Within course	24.6	23.0	29.7	22.6	100% (N=547)
Within group	4.7	4.4	5.0	4.1	
Algebra II					
Within course	15.6	11.5	37.2	35.8	100% (N=1630)
Within group	8.8	6.6	20.2	18.2	
Calculus; Other advanced courses					
Within course	16.0	10.1	34.4	39.5	100% (N=821)
Within group	4.6	2.9	9.4	10.1	
TOTALS, WITHIN GROUP	100% (N=2824)	100% (N=2870)	100% (N=2992)	100% (N=3213)	
PERCENT EACH GROUP REPRESENTS IN SCHOOLS	23.7	24.1	25.1	27.0	

to continuing disparities among black students, and although the odds seemed to favor black females, a chasm separated those females from their white counterparts.

Within Group Comparisons

The same outcomes appeared in the calculations based on group rather than course totals. Over half of the black males, compared with one-fifth of the white males, were in general mathematics. At the other end of the ladder the distributions were reversed: a larger fraction of the white males than of the black males were taking calculus and other top level courses. White females were rather equally arrayed across four courses: general mathematics, beginning algebra, geometry, and algebra II; that was not true for black females, however. Instead, paricipation rates for the latter group declined from one level to the next in the sequence. In comparison with the black males, nonetheless, black females were more likely to be in higher level courses.

In summary, three patterns stand out for the overall sample. First, black females were underrepresented in elective courses. This is evident in the results for top level courses, discussed to this point, as well as those for the advanced and most selective courses. The findings for the advanced courses show that black females comprised a smaller proportion of the enrollees than one might have predicted, based on their representation in the sample schools. Had the advanced enrollment equaled the population distribution, the black female mean would have been 100; in actuality it was 77.3 (see Table 4). The advanced enrollment figure just described reports the

TABLE 4. ENROLLMENT IN ADVANCED MATHEMATICS COURSES IN PROPORTION TO REPRESENTATION IN SCHOOL POPULATION, BY RACE/SEX CATEGORY AND SCHOOL

	Race/Sex Category			
School	Black Females	Black Males	White Females	White Males
1	23.0	69.2	135.6	190.0
2	95.6	38.7	118.5	112.3
3	30.0	10.0	109.4	152.5
4	155.0	106.4	51.5	78.7
5	75.1	61.3	127.7	123.4
6	114.4	68.5	112.6	107.4
7	81.9	65.7	117.7	94.9
8	60.6	79.3	120.0	173.8.
9	91.9	72.8	115.5	115.5
10	48.3	24.2	127.1	112.9
11	90.0	86.5	146.8	92.6
12	32.9	20.6	136.4	139.1
13	51.3	25.2	87.8	148.8
14	126.1	75.4	83.0	116.8
15	74.3	117.9	63.3	191.7
16	40.0	10.0	199.6	176.1
17	28.8	22.4	118.9	133.3
18	53.3	35.4	178.2	250.0
19	114.9	69.1	64.8	194.3
20	159.2	52.3	71.7	115.0
Mean	77.3	55.3	114.0	140.9
Std. Dev.	37.9	30.0	35.5	42.2

Advanced courses are those for which students had to have had algebra I and one course beyond it. The table reports the proportion of all advanced enrollees that each race/sex category represented in comparison with its proportion in the school. The formula is as follows:

$$\frac{\text{proportion in advanced courses}}{\text{proportion in school}} \times 100$$

within-course results. The trend obtains as well when we look at enrollment in the most selective courses, using the within-group data. Of the black females who were taking mathematics, fewer were in the most selective courses than was true for white students of both sexes (see Table 5).

The second pattern shows that although the black female rates lagged behind those for white males and females, they exceeded the rates for black males. Consider again the advanced course enrollments, as reported in Table 4. If 100 represented a balance between the enrollment and proprtion within the school, then the black male figure was even more imbalanced than the black female one: it was only about 50 percent of the expected figure. Tables 4 and 5 show that black males were relatively sparse in the higher level courses. What they do not illustrate is that those students — even more so than black females — were disproportionately found at the lower end of the course hierarchy. If we substitute general mathematics enrollment for advanced enrollment in the formula for Table 4 the following are the results: black males -- 148.9; black females — 123.2; white males -- 70.4; and white females — 63.7. The figures indicate that black students, and especially black males, comprised a larger fraction of the general mathematics enrollees than one might have predicted on their basis of their distribution in the schools.

The third pattern is this: the trends were more similar between black males and females than between black and white females. The results reported in Table 5 demonstrate the point. The mean enrollment figure for white males as well as for white females differed significantly from the figure for black females; the black male figure was not significantly different from the black

TABLE 5. ENROLLMENT IN THE MOST SELECTIVE COURSES AS PROPORTION OF TOTAL MATHEMATICS ENROLLMENT, BY RACE/SEX CATEGORY AND SCHOOL

	Race/Sex Category					
School	Black Females	Black Males	White Females	White Males	Total	
1	5.0	10.7	7.7	12.1	9.3	(171)[1]
2	16.1	15.0	18.0	14.3	16.0	(200)
3	7.9	4.5	19.0	24.2	19.3	(368)
4	16.2	10.5	19.2	37.8	17.4	(275)
5	14.8	15.5	36.2	39.4	27.4	(448)
6	3.6	2.8	2.3	10.8	5.0	(181)
7	11.2	11.9	6.3	7.3	7.6	(772)
8	3.7	5.6	6.4	12.9	6.6	(665)
9	10.0	10.6	22.0	24.4	17.6	(131)
10	10.5	7.4	19.7	23.2	19.3	(398)
11	8.7	12.8	13.9	17.1	12.4	(217)
12	8.5	5.7	21.2	20.0	17.9	(1048)
13	4.6	2.6	15.5	22.3	14.0	(485)
14	16.1	10.7	11.3	14.7	13.1	(464)
15	5.5	9.5	3.1	22.7	8.1	(308)
16	20.0	9.1	22.1	23.1	21.4	(173)
17	6.9	4.5	16.0	16.8	15.0	(748)
18	4.2	3.7	7.6	13.5	6.3	(271)
19	8.4	10.0	14.3	3.8	8.6	(151)
20	7.5	3.7	3.6	5.8	5.3	(543)
Mean	9.5	8.3	14.3*	18.3**	13.4	
Std. Dev.	4.7	3.9	8.2	9.1	6.0	

The most selective courses are those in which students had to have had algebra I and two courses beyond it. The calculations for each category are based on:

$$\frac{\text{number in the most selective courses}}{\text{number in all courses, algebra I and above}}$$

*Significantly different from black female mean at .01 level
**Significantly different from black female mean at .001 level

[1]Numbers in parenthese represent number of students on which the total is based.

female one, however. The results of correlation analysis using enrollment in the top level courses confirm the finding. In those courses, black male and female counts were highly correlated ($r = .74$), as were the ones for white males and females ($r = .82$). But across racial lines the correlations were weaker: black and white males: $r = .23$; black and white females: $r = .31$.

MINORITY FEMALE ENROLLMENT IN SCIENCE

Within Course Comparisons

The four race-sex categories were not evenly distributed in the science curricula. Of the nearly 9,000 students in science, 30 percent were white male; 28 percent white female, 21 percent black male, and 21 percent black female. Apparently, white students were more likely to be in science courses than were black students. Nor did the distribution in each course match that for science in general. For biology, the numbers were close to the overall proportions: 29 percent white male, 29 percent white female, 21 percent black male, and 21 percent black female (see Table 6). But black students outnumbered white males and females in general science, while white students were nearly twice as likely to take chemistry: over three-quarters of the students in chemistry were white. In physics, too, the number of white students far outdistanced the number of black students; the ratio was at least three to one. Yet, in one respect the pattern for physics departed significantly from that for chemistry and for general science. For those two subjects, the numbers of white males and females were similar, as were the

TABLE 6. WITHIN COURSE AND WITHIN GROUP DISTRIBUTION, AGGREGATE SCIENCE DATA

COURSE	GROUP				
	Black Females	Black Males	White Females	White Males	Totals, Within Course
General science					
Within course	34.5%	33.5%	13.9%	18.1%	100% (N = 591)
Within group	11.0	10.5	3.2	3.9	
Physical science					
Within course	23.0	27.7	24.1	25.2	100% (N = 1633)
Within group	20.2	24.0	15.5	15.2	
Biology					
Within course	21.0	21.4	28.9	28.6	100% (N = 4682)
Within group	53.0	53.2	53.5	49.6	
Earth science					
Within course	20.2	15.4	33.0	31.4	100% (N = 357)
Within group	3.9	2.9	4.7	4.1	
Chemistry					
Within course	12.8	10.2	37.5	39.5	100% (N = 1272)
Within group	8.8	6.9	18.8	18.6	
Physics					
Within course	12.9	10.6	52.3	24.2	100% (N = 442)
Within group	3.1	2.5	4.2	8.5	
Totals, Within Group	100% (N = 1855)	100% (N = 1886)	100% (N = 2532)	100% (N = 2704)	

counts for black males and females. Of the physics enrollees, however, white males represented almost one-half, white females nearly one-quarter, and black males and females, one-eighth each. As this indicates the male-female ratio was nearly equal among blacks, but not among whites. In summary, the within course trends showed that the science students were not evenly arrayed across the courses. General science courses drew a disporportionate number of black students--male and female--and physics attracted disproportionately more white males.

In science as in mathematics, minority female representation in the school population outdistanced the advanced course sums. Furthermore, the means were very similar: for both science and mathematics the number of minority females in advanced courses was about three-quarters of the expected count (see Table 4 and 7). White females were enrolled in the science courses at about the expected rate, while white males had a participation rate above the expected one. There as with mathematics, black males were in the rear; their science participation rate (64.8) was slightly higher than their mathematics rate (55.3), however.

Within Group Comparisons

Analyses based on the distribution of a race-sex category across courses confirmed the results already discussed. Of the black students in science, about 11 percent of the males and the same percent of the females were taking general science; for white students the male and female figures were just above 3 percent. The fraction of white students in chemistry (18 percent for males and females) was twice that for both black males (7 percent) and black

TABLE 7. ENROLLMENT IN ADVANCED SCIENCE COURSES IN PROPORTION TO REPRESENTATION IN SCHOOL POPULATION, BY RACE/SEX CATEGORY AND SCHOOL

School	RACE/SEX CATEGORY			
	Black Females	Black Males	White Females	White Males
1	70.0	111.8	90.2	131.2
2	46.3	23.1	275.9	174.3
3	30.0	30.0	102.3	152.0
4	150.0	147.2	30.2	60.3
5	59.6	11.2	134.5	129.4
6	116.9	71.5	99.2	114.4
7	92.3	80.9	57.0	141.8
8	89.1	67.3	105.3	164.8
9	71.7	81.3	84.8	156.9
10	38.4	32.9	103.9	136.8
11	--	--	150.4	100.0
12	150.0	25.7	130.9	144.0
13	149.3	79.0	86.6	104..9
14	110.4	103.0	105.7	95.4
15	97.4	85.5	64.5	194.8
16	63.5	31.7	109.6	93.9
17	16.2	32.3	102.3	148.1
18	96.4	96.4	140.0	46.6
19	137.3	68.6	64.5	113.0
20	73.1	115.8	85.1	125.4
Mean	70.1	64.8	92.4	126.4
Std. dev.	39.5	32.9	50.2	35.6

females (9 percent). Only a handful of the black males (2 percent), black females (3 percent), and white females (4 percent) were in physics; in contrast, 8 percent of all of the white males were physics students. It appears from the results on general science, chemistry and physics that blacks were more likely to enroll in general than in specialty courses. This could not be determined, however, given that such specialty courses in biology as marine biology, anatomy and physiology, and microbiology were coded with more general ones.

Certain conclusions do emerge, nonetheless. First, for both sexes and both races enrollment in the biological sciences far exceeded that in the physical sciences. Second, slightly more of the females than of the males were in earth science, but that subject drew relatively few from any of the race-sex categories. Finally, for most subjects the male-female differences within race were smaller than the racial differences. In chemistry, for example, the correlation coefficient for black males and females was .91; for white males and females, .67; and for black and white females, .42.

IV. VARIATIONS AMONG SCHOOLS IN ENROLLMENT PATTERNS

Black female rates in both mathematics and science trailed those for white students of both sexes in the aggregate sample. But it was obvious that large numbers of students from both racial groups were taking no more than the minimal requirements for graduation. It was the case, too, that the rates -- for black females as well as for the other categories -- varied sharply from one setting to another. The discussion now turns to the data from individual schools to reflect on the conditions that seemed to promote the enrollment of black females on both a relative and an absolute basis. As described in an earlier section, the study focused specifically on the influence of organizational conditions.

VARIATIONS IN MATHEMATICS ENROLLMENT

The hypotheses predicted a positive relationship between black female enrollment in elective mathematics courses and three organizational variables: teacher satisfaction, or the school climate; teacher participation in decision making; and level of teacher experience. It follows, then, that the study assumed a positive relationship among those three variables as well. The results upheld the assumption in some instances but not in others. Satisfaction had a positive correlation with participation ($r = .33$) but not with the experience measures (see Table 8). Participation was positively associated with average teacher experience at the present school but not with the other experience measure. These findings indicate that not all of the

TABLE 8. CORRELATION MATRIX, ORGANIZATIONAL, PROGRAMMATIC, AND COMPOSITIONAL VARIABLES

	Satis-faction	Involvement	Experience, Present School	Experience, Overall	Percent Black	Ratio of Math/Science Teachers
Teacher satisfaction	--	.33	-.14	-.12	.12	-.04
Teacher involvement in decision making			.28	.03	-.12	-.34
Level of teacher experience, present school				.48	-.25	-.12
Level of teacher experience, overall					-.21	-.22
Percent black in school population						-.12

organizational variables could have had positive effects on black female enrollments.

Let us look at the relationships between the three variables and mathematics enrollment. First, the climate measure -- level of teacher satisfaction -- was unrelated to enrollment ($r = .09$). Thus, the results do not support the first hypothesis; but neither do they disprove the importance of climate. Quite possibly, the results would have differed had the study used other measures of school climate. Indeed, the visits suggested that school differed widely in academic and disciplinary atmosphere; this would indicate a need for continued attention both to the measurement of climate and to determining whether it does in fact make a difference for minority female participation in mathematics. Second, the decision making variable had a negative association with enrollment ($r = -.22$), a result inconsistent with the second hypothesis. The negative association found between involvement and enrollment might be consistent with an argument in the literature that effective schools tend to have strong administrators. As noted earlier, Wellisch et. al., maintain that school management is most successful when teachers and administrators share in the making of decisions. It could be, then, that the high enrollment schools were settings in which such sharing was characteristic. Both of the experience measures were positively associated with black female enrollment in top level courses. The measure, average experience at the present school correlated .35 while, the other measure, total experience, resulted in an r of .25. The compositional measure had a very weak negative association with enrollment.

To determine whether the results were dependable, the study looked at the relationship between the given organizational measures and another mathematics enrollment measure: black female enrollment in algebra II. With this measure, climate had a slight negative relationship ($r = -.14$), decision making had no relationship ($r = .09$), nor had the measure, total experience, ($r = .03$), while the alternative experience measure had a positive relationship ($r = .40$). The results using both measures of enrollment provide support for the third hypothesis -- with experience in present school as the measure — but not for the first two.

The study centered only partly on the relationship of single variables to enrollment. Perhaps even more importantly, it compared the importance of the organizational variables to one another and to the compositional and programmatic measures. The fourth hypothesis predicted that the organizational ones would be more important to enrollment than would the other categories. To determine the relationship between given school characteristics and enrollment, the organizational, compositional, and programmatic variables described earlier were entered into a regression equation in which black female enrollment in the top level courses was used as the dependent variable.

Three of the organizational variables bore a stronger relationship to enrollment than did the programmatic and compositional measures (see Table 9). Concretely, level of teacher experience at the present school, teacher involvement in decision making,and teacher satisfaction accounted for more of the variance in enrollment than did the relative size of the mathematics and science faculty or the ratio of black to white students. The measure of total

TABLE 9. REGRESSION OF BLACK FEMALE ENROLLMENT IN ADVANCED MATHEMATICS COURSES ON ORGANIZATIONAL, PROGRAMMATIC, AND COMPOSITIONAL VARIABLES

	I			II			III		
I. Organization	Beta	Standard Error	F	Beta	Standard Error	F	Beta	Standard Error	F
Level of teacher experience, present school	.53	.003	4.969*	.53	.003	4.645*	.50	.004	2.672
Teacher involvement in decision making	-.48	.000	3.676*	-.51	.000	3.572*	-.51	.000	2.812
Teacher satisfaction	.32	.000	1.738	.32	.000	1.701	.33	.000	1.461
Level of teacher experience, overall							.04	.003	.027
II. Programmatic: ratio of math/science teachers to all teachers				-.10	.260	.164	-.09	.300	.116
III. Student Composition: percent black in school population							-.03	.033	.016
R^2	.32			.33			.33		
Adjusted R^2	.17			.12			-.03		
F	2.20			1.60			.91		

*$p < .05$

experience was not significant in the regression analyses, primarily because of its high correlation with the alternative experience measure.

Overall, the results support the fourth hypothesis. But one should keep in mind two caveats. First, some of the variables did not have the positive effect the hypothesis assumed; second, the organizational variables collectively could not account for most of the variance among the schools. To understand better the operation of the variables that did seem to be important as well as to indentify potentially more significant influences, we followed another tack: we divided the sample into high and low enrollment schools and examined some of the differences between them.

Analyzing High and Low Enrollment Schools

A school was identified as a high enrollment school if (1) black female enrollment in the advanced courses was at least 90.0, i.e., it was at least 90 percent of the expected figure (see Table 4); and (2) the enrollment was based on a count of 10 or more persons. The second criterion was introduced because the enrollment could have been proportionate yet small. In school 6, for example, black females were as evenly distributed in the advanced courses as they were in the total school population, but there were few students of either race or sex in those courses. A school was selected as a low enrollment school if (1) black female enrollment in the advanced courses was 50.0 or lower; (2) enrollment in the most selective courses was more than one standard deviation below the group mean (see Table 5); and (3) there were five or fewer black females among the enrollees in advanced courses. On the basis of the criteria, six schools emerged as high enrollment schools and another

six as low enrollment ones; the remaining eight were considered to be intermediate.

The high and low schools were compared with reference to several organizational, compositional, and programmatic measures. The organizational measures used were level of formal communication (average number of meetings and committees attended by each teacher), level of professionalism (average number of teachers with post-graduate degrees) and administrator support for the academic program. The first two measures were derived from the questionnaire responses of all teachers; the responses of the mathematics teachers did not differ from those of their colleagues. The last item came from the informal interviews held with teachers and principals; the interview probed to see if the principal gave great weight to the academic program and whether he or she had taken any specific actions to enhance or reward achievement in mathematics and science.

In terms of student composition, the socio-economic makeup of each student body was determined. The information came from the informal interviews as well as from school lunch data. It was assumed that the larger the proportion of students who were receiving free or reduced price lunches, the lower the average socio-economic level of the student body. Finally, the characteristics of the mathematics program examined were the depth of the program, the degree of staff specialization, and the specificity of the graduation requirements. Depth was indicated by the number of courses offered that had least three mathematics prerequisites, and the proportion of that total represented by honors and advanced placement courses. Specialization referred to the distribution of courses among teachers. The fewer the number

of different preparations per teacher the more specialized the mathematics faculty. Specificity had to do with the number and type of mathematics courses required for graduation. The larger the number and the greater the limit on options, the higher the level of specificity.

Differences Between High and Low Enrollment Schools

Of the various measures, only a non-empirical one -- principal support -- seemed to differentiate the two categories of schools. The schools were quite similar on three of the variables: staff professionalism, specialization, and specificity of graduation requirements. In nearly every school most teachers had taken courses beyond the bachelor's degree, and there were too few with doctorates to make an analysis of them worthwhile. Generally, too, all teachers were giving some general mathematics classes along with their higher level courses; few schools had assigned certain teachers exclusively to one course level. Although some of the schools required specific science courses for graduation, the mathematics requirements were rather non-specific: four of the high enrollment schools and three of the low enrollment schools required two years of mathematics and all left the choice of the courses up to the students.

Schools differed on other measures -- level of communication, socio-economic make-up of student body, and depth of the mathematics program -- but the differences were unrelated to enrollment contrasts. The high enrollment category contained schools with relatively large fractions of lower-income students, but it had higher-income schools as well. One high enrollment school (School 2) offered several honors and advanced placement

courses, but so did a low enrollment school (School 10).

Principal involvement emerged as a potentially influential force. Rather uniformly, the staff in the high enrollment schools could point to specific actions the principal had taken in support of the academic program. The principal of a small rural school had arranged after-school transportation so that students could learn how to prepare for the Scholastic Achievement Test. Another worked to prevent the district from giving resources disproportionately to a school attended primarily by the children of professionals.

In some of the schools that we visited, the principal had expressed strong interest in the academic performance of students by creating school wide awards for mathematics and/or science; by emphasizing mathematics and science contests; or by establishing special workshops for teachers and students. Not all of the principals who seemed to be supportive took actions geared specifically to mathematics and science. In some instances, they made course assignments long enough in advance to give both teachers and students time to plan their programs. Sometimes, the principal showed that he or she expected the chairperson of the department to be more than a figurehead; the principal looked to that individual to work cooperatively with the other teacers in setting department-wide goals. Possibly, principals can help create a climate that is conducive to planning and to innovation; and it is in such a climate that the needs and interests of the potential dropouts from mathematics--minority female students--are most likely to be addressed.

Conversations with teachers and administrators corroborated what the data seemed to indicate: fewer students were taking higher level courses than were eligible to do so. Generally, the school personnel attributed the dropoff to

one factor: lack of student interest. In one school after another mathematics teachers described and decried the process through which students chose to complete only enough mathematics courses to graduate. Some schools offered a limited number of level courses, ostensibly because there was no demand for them. Still, it was obvious that some schools would not have been able to meet the demand even if it were made, for their mathematics teachers were needed for the remedial courses the school had had to institute, often in response to competency-based examinations. In many of the schools the number of students needing remediation in mathematics exceeded the number with the background for courses such as statistics or computer mathematics. In those cases, the resources had to be allocated at the bottom rather than at the top of the ladder. It would seem, then, that motivational problems were not the only forces limiting the kind and number of courses offered at the upper end of the range.

VARIATIONS IN SCIENCE ENROLLMENT

The organizational variables had a different relationship to science than to mathematics enrollment. With black female enrollment in physics as the dependent variable, the following resulted. The independent variable with the strongest positive correlation ($r = .30$) was the satisfaction measure. The next was experience at present school ($r = .14$) and then decision making involvement ($r = .10$). The fourth organizational measure -- total experience -- had no relationship to enrollment. The programmatic measure -- mathematics/science teacher ratio -- had the highest correlation coefficient

of any of variables, but it was negative: -.43. As with the results for mathematics, the composition of the population, as measured by proportion black in the student body, was unrelated to enrollment: r = -.08.

Although for mathematics, climate and enrollment in top level courses were not related, they were in the case of science; hence, the science results supported the first hypothesis. Similarly, the relationship between decision making and science enrollment was small but positive, whereas it was negative for mathematics enrollment. But the science correlation was too small to suggest that the second hypothesis received strong support. The experience measure that had a strong relationship to the mathematics outcome also was positive in the case of the science measure; but as with the decision making coefficient it was too small to indicate confirmation of the third hypothesis.

One should surmise from the preceding that the regression results for science did not correspond with those for mathematics. In the stepwise regression model that used science enrollment as the outcome, the programmatic measure entered the analysis first; with mathematics enrollment it was the last of the six variables (See Table 10). Satisfaction entered the science analysis at the second step and the mathematics analysis at the third; but in both instances it had the same effect on the amount of variance explained: the change in R^2 was .08. Finally, the full set of variables accounted for more of the variance in science enrollment (R = .63) than in mathematics enrollment (R = .58).

Analyzing High and Low Enrollment Schools

The procedures used for identifying schools with high mathematics enrollment were followed as well for selecting high science enrollment

TABLE 10. REGRESSION OF BLACK FEMALE ENROLLMENT IN PHYSICS ON ORGANIZATIONAL, PROGRAMMATIC, AND COMPOSITIONAL CHARACTERISTICS

	Beta	Standard Error	F
Ratio of math/science teachers to all teachers	-.57	.47	4.727*
Teacher satisfaction	.42	.00	2.738
Percent black in school population	-.23	.05	.815
Teacher involvement in decision making	-.33	.00	1.351
Level of teacher experience, present school	.29	.01	1.046
Level of teacher experience, overall	-.26	.01	.866
R^2	.40		
Adjusted R^2	.08		
F	1.24		

*$p<.05$

settings. Low enrollment schools were those in which black females enrollment in the advanced courses was 50 percent or less of the expected figure (see Table 10) and the total number of black females in such courses was less than 10. These criteria yielded 7 high enrollment schools, 5 low enrollment ones, and 8 intermediate schools.

Schools that had high minority female enrollment in science were not necessarily the ones with high mathematics enrollment counts. Different findings illustrate this. First, there as no correlation between enrollment in calculus and enrollment in physics ($r = .04$). This resulted partly from the very low counts for physics enrollment; in other words, the figures rather consistently were low for all of the schools.

Second, the set of 7 high science enrollment schools contained only one from the set of high mathematics enrollment schools. Indeed, one of the schools in which black females were well represented in mathematics had a far lower science enrollment rate than one would have predicted. Yet, some consistencies resulted. None of the schools with high science enrollment appeared on the list of low mathematics enrollment schools; instead, six were in the intermediate category. Although one of the schools at the lower end of the science spectrum, was at the opposite pole for the mathematics count, the remaining 4 also had low mathematics counts. This implies that the forces associated with enrollment patterns in mathematics are likely to be important in the case of science as well.

CONCLUSIONS

The results seem to bolster the contention that school-level forces, especially organizational ones, deserve more systematic study. This is not to suggest that research centered on individual attributes or on school composition is unnecessary. Ideally, we need to know how individual, compositional and organizational factors all interact to produce positive student outcomes. Nor are the specific measures used here presented as model ones; other approaches to organizational issues are both possible and potentially useful. The point to be made is that, as some research indicates, school structures and processes should not be ignored.

The findings hint that the conditions which benefit black female students might benefit non-black students as well. Consider the fact that the schools with high black female enrollment -- based on the within-group measure -- usually had high white enrollment, too. In Schools 4 and 16, where significant fractions of the black female enrollees were in the most selective mathematics courses, there were sizeable counts for white males and females also. It appears that the benefits accrue more to white students than to black females and more to the latter than to their male peers. But one need not assume that by enhancing black student participation one will thwart white student involvement.

The study examined participation but not achievement in mathematics and science. Obviously, enrollment in a course need not mean mastery of the subject matter, not does it imply exposure to competent teaching. More work is needed on the conditions that promote achievement, but the matter of mere

participation should not be ignored. As Fennema has maintained, students who at least have taken a course such as calculus have an advantage over those who have not. The enrollees have some acquaintance with the concepts and approaches in the subject area and a wider array of occupations open to them.

When judged against an ideal standard, the black female rates uncovered in this research warrant concern, for they show that students were dropping off at every level and thus closing off options for themselves.

Even though white participation overshadowed that of blacks, large numbers in both races failed to progress up the hierarchy. Consider the scarcity of white males and females in the most advanced courses. We need, then, to raise the participation rates and thus increase the larger choices of all students.

FOOTNOTES

1. Unfortunately, the data are not detailed for the various Hispanic groups.

2. For reviews of the Project Talent and NLSMA results see Fennema (1980) and Fox (1981). Other analyses reporting male-female differences in participation include Ernest (1976, 1980) and Konsin, cited in Fennema (1980).

3. Also see Fennema and Carpenter (1981) for similar results based on the NAEP data.

4. The conceptual framework for the study appears in Parsons, Kaczala, and Meece, 1982; and in Meece, et al., 1982.

5. Nelson (1978) also carried out a social-psychological study on a group of black fifth and eleventh graders in New Orleans.

6. For critical analyses of the report see Sociology of Education 55 (April/July, 1982).

7. A few examples of the national attention include the formation in early 1982 of a Commission on Precollege Education in Mathematics, of a convocation on precollege education in mathematics and science by the National Academy of Science and the creation of a Coalition of Affiliates for Science and Mathematics Education by the American Association for the

Advancement of Science. In addition, several bills are being introducted in Congress that have to do with science and engineering education. Many of the efforts in engineering are coordinated through the National Action Council for Minorities in Engineering. The coordinators of precollege science, mathematics, and technology program formed in 1979 the National Association of Pre-College Directors (NAPD).

8. At this stage of the research, Mary Evans Sias was the project assistant. In addition, Rubie Harris assisted in the design and execution of the survey.

9. Harold Gates was project assistant during this stage. Helping us make the visits were Michele Trepanier, Hazel Symonette, and Marguerite Btyan.

10. In a 1967 study of black high schools in Louisiana, Crawford found the following distribution: general mathematics - 39.8%; algebra I - 27.1%; algebra II - 10.3%; and trigonometry/advanced mathematics - 4.6% (Crawford, 1967).

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Women and Minorities in Science and Engineering

1982 National Science Foundation

Appendix A

PARTICIPATING SCHOOLS

Alcoa High School
Alcoa, Tennessee
Principal: Mr. Otis C. Abbot, Jr.

Americus High School
Americus, Georgia
Principal: Mr. James Fussell

Austin East High School
Knoxville, Tennessee
Principal, Mr. James Thacker

Bastrop High School
Bastrop, Louisiana
Principal: Mr. Lee Roy Whorton

Battery Creek High School
Beaufort, South Carolina
Principal: Mr. James Rogers

Bolivar High School
Rosedale, Mississippi
Principal: Mr. Ralph Mills

Brunswick High School
Lawrenceville, Virginia
Principal: Dr. William Powell

Carroll High School
Monroe, Louisiana
Principal: Mr. Joel Harris

Centennial High School
Compton, California
Principal: Mr. Willard McCrumby

Joseph Clark High School
New Orleans, Louisiana
Principal: Mr. Dennis Minor

Cohn High School
Nashville, Tennessee
Principal: Mr. Fred Hatchett

Compton High School
Compton, California
Principal: Mr. Willie Hill

Dominguez High School
Compton, California
Principal: Mr. Fred Eater

Dudley High School
Greensboro, North Carolina
Principal: Mr. Earl Crotts

Eunice High School
Eunice, Louisiana
Principal: Mr. Raymond Fontenot

Gaffney High School
Gaffney, North Carolina
Principal: Mr. Wayne Whiteside

Hearne High School
Hearne, Texas
Principal: Mr. Leon Jackson

Henry County High School
McDonough, Georgia
Principal: Mr. Randall D. Ponder

Hillsboro High School
Nashville, Tennessee
Principal: Mrs. Jean Litterer

Hopewell High School
Hopewell, Virginia
Principal: Mr. Ronnie Bugnar

Hunter-Huss High School
Gastonia, North Carolina
Principal: Mr. Russell Clark

John F. Kennedy High School
New Orleans, Louisiana
Principal: Dr. Nolen Morgan

Maplewood High School
Nashville, Tennessee
Principal: Dr. Riley Elliott

McGavock High School
Nashville, Tennessee
Principal: Mr. Chester A. Lefever

Mt. Healthy High School
Cincinnati, Ohio
Principal: Mr. James Bischoff

New Iberia High School
New Iberia, Louisiana
Principal: Mr. Murle McClelland

F.T. Nicholls High School
New Orleans, Louisiana
Principal: Mr. Russell Constanza, Jr.

Northampton High School
Eastville, Virginia
Principal: Dr. Richard Sternberg

Northwest High School
Littleton, North Carolina
Principal: Mr. H. Wood

Norview High School
Norfolk, Virginia
Principal: Mr. Charles W. Perdue

Page High School
Greensboro, North Carolina
Principal: Mr. Robert Clendenin

Pearl High School
Nashville, Tennessee
Principal: Mr. Leslie Carnes

Plaquemine High School
Plaquemine, Louisiana
Principal: Mr. L.J. Raymond

Quitman High School
Marks, Mississippi
Principal: Mr. S.A. Wright

Reid Ross High School
Fayetteville, North Carolina
Principal: Mr. Jack McGinley

Shelby High School
Shelby, North Carolina
Principal: Mr. Frank McDaniel

E.E. Smith High School
Fayetteville, North Carolina
Principal: Mr. John Griffin

South High School
Youngstown, Ohio
Principal: Mr. Richard Devincentis

Thibodaux High School
Thibodaux, Louisiana
Principal: Mr. Luke Ford

Tubman High School
Compton, California
Principal: Mr. Russell Alexander

Wakefield High School
Arlington, Virginia
Principal: Mr. Victor Blue

O.P. Walker High School
New Orleans, Louisiana
Principal: Dr. Robert Gaut

Warrensville Heights High School
Warrensville, Ohio
Principal: Mr. Clarence C. Rogers

Xenia High School
Xenia, Ohio
Principal: Mr. Ronald Roth

APPENDIX B - SCALES USED IN STUDY

The two indexes consisted of the following items:

Decision-making involvement index

In your school, what is your involvement in each of the following:

1. The development of the budget for your department, unit, or program.
2. The establishment of student disciplinary rules.
3. The setting of goals for your unit or program.
4. The development of procedures for reporting student progress.

Reponse categories

1. No involvement
2. Little involvement
3. Some involvement
4. Substantial involvement

Satisfaction index

How satisfied are you with each of the following?

1. The extent to which you are able to meet your students' academic needs.
2. The academic performance of black students in your school.
3. The academic reputation your school has in the community.
4. The counseling services your school provides.

Response categories

1. Very dissatisfied.
2. Dissatisfied
3. Satisfied
4. Very satisfied